Wood, Robert S.

The soil considered as a separate and distinct department of Nature.

1850.

THE SOIL,

CONSIDERED AS A

SEPARATE AND DISTINCT DEPARTMENT OF NATURE,

BY

ROBERT. SERRELL. WOOD,

Corresponding Member of the National Institute.

WASHINGTON, MARCH, 1850.

The most palpable source of nutrition to all created beings was supposed by the ancients to possess the attributes of vitality; it was therefore an amiable weakness on their part to personify the Earth, and to hold her in peculiar veneration. Modern science has banished this beautiful sentiment from its stern philosophy, but it can never invalidate the fact that there are certain ingredients of the soil (whatever be their origin) which claim intermediate rank between matter in such states of combination as the chemist can produce by synthesis, and the lowest specimens of vegetable organisms: neither has it yet successfully proved that the same elements in other shape than the organic salts of humus contribute with equal efficiency to the luxuriance of vegetation, although there is evidence in volcanic and other localities to show, that an excess of either free carbonic acid gas, or ammonia, or water, even when the other minerals present suffice for the wants of plants, is injurious to the highest degree. A greater proportion than at present of those gases and vapours in the atmosphere, and consequently in the soil, may have favored the earliest denizens of our globe: those tribes have now nearly passed away, or their constitution has been modified with modifications of climate, &c.

A just appreciation of fossil organic remains has elicited a probable truth, that function and organization proceed through both kingdoms of nature by parallel lines of advancement, observable since the different periods of the world at which they respectively commenced their existence. It would seem as if some general law, harmonizing with the earth's progress in its physical capacity, governed the succession of these products, an idea which is further supported by their gradual development at the present day from the germinal to a perfect state. We should also bear in mind the remarkable fact, that animals and vegetables are blended together so as to render any attempt to define their distinguish-

ing properties utterly futile. Vegeto-animals have been fully recognised by naturalists; and we are next led to inquire whether the soil, forming a connection between organized and unorganized matter, partakes of a *vegeto-mineral* character in the highest acceptation of the term.

The animal department, although indebted for its growth and prime condition to azotized aliment approximating more or less in its nature the tissues themselves, borrows, from vegetables especially, hydro-carbonaceous substances of a less complex composition, a portion of which is converted into fat, another portion is directly oxidized and excreted, while a third is presumed, in the case of the lowest animals, to be convertible by means of ammonia into gelatine, &c., their integuments corresponding with those of plants as surfaces absorbent of nourishment, sufficiently at least to establish a close relation between both races in this respect as well as in their both inhaling oxygen.* Again, the vegetable department in its highest range, although dependant upon rich mould or organic manures for its most efficient support, (as man and some other animals are upon flesh,) draws from the atmosphere elements convertible into cellulose, &c., indicating the claims of animals upon vegetables, of vegetables upon the soil, and, as I shall endeavor to show, the ultimate dependance of the soil upon the atmosphere. Nature evidently proposes more than one resource for the maintenance of her creatures; and unity of design, which pervades the works of creation, would suggest that, although the soil receives its most unequivocal accessions from the debris of plants, it nevertheless allows the crude materials of air to circulate within its pores, and to form more notable combinations. Animals, vegetables, and the soil are constituted in large proportion of particles, which have possessed, but which no longer retain, the usual characteristics of life—particles, be it observed, which threaten to resolve themselves into simpler forms, unless the tendency to disintegration be

---

*The oxidation of the hydrocarburets is generally believed to liberate caloric in living bodies as a primary result, but I respectfully maintain that it, in the first instance, causes the surrender of electricity which was previously combined; heat consequently becomes a secondary effect, of an altered consistency or composition in solids or fluids, whereby their specific capacity for caloric is affected. The temperature of animals is exaggerated by physical exertion, which causes the contract on of muscles and a more rapid circulation of the blood. A large portion of their food is already combined with oxygen in the proportion to form water; no heat is therefore evolved from this source, and the separation of free water from their surfaces in the shape of vapour produces a reduction of temperature perhaps equivalent to the heat generated by the conversion of venous into arterial blood. The slow reactions between highly constituted substances may be identical in a chemical point of view with ordinary cases of combustion, but the results very different; the amount of heat liberated being proportionate to the greater or less competency of conducting media to carry off the electricity set free, or of other contiguous molecules in the circulation or elsewhere to appropriate that imponderable by forming new combinations. And here I may be permitted to add, that if the solution of a simple metal in the voltaic apparatus liberates a force which, on being conducted by a special arrangement of wire around an enclosed bar of iron, *magnetizes it, a fortiori* the resolution of more complex particles, such as those contained in the animal circulation, might be supposed capable of contracting (magnetizing) a muscle enclosed within a network of conducting nervous filaments. A ganglion is the voltaic apparatus, certain constituents of the blood electrolytes, the motor and sensitive nerves conducting media, and the muscle, which is insulated by cellular matter and ligament, a magnet. The contraction of a muscle or a congeries of muscles would not necessarily diminish the volume of their mass, because their reduction of size only tends to enlarge the capacity of the surrounding cellular substance; free ingress is therefore allowed to the blood between the fibres, and consequently greater efficiency produced in the parts.

counteracted by a force of an opposite kind. The soil possesses no evidence of organization either in mass or in detail; but organization may mark grades of development without being indispensable to characterize living matter. Nothing can be more indefinite than even the essential properties of life. Can physiologists determine at what precise moment the vital principle is surrendered by a piece of muscle cut from the leg of a healthy animal? The separation of a part merely shortens its term of existence by destroying perhaps the faculty of self-preservation or reproduction. Where then shall we find the first link in the self-supporting chain of vital products? Are we to consider the vesicles or cells which the microscope discovers almost everywhere on the earth's surface as exhibiting the simplest manifestations of life, or may we refer its rudiments to the corpuscles of blood, or to certain constituents of sap?

I propose to regard the soil as a creature *sui generis*, sustaining living bodies whilst it is itself sustained by them. Its proportions are limited by the means of increment placed at its disposal. If the natural history of soil be studied, we find that although it may increase enormously under certain conditions, and although its term of maturity may be prolonged to an apparently indefinite extent, its ultimate dissolution, in whole or in part, is a matter of as much certainty as the lapse of ages. Organized bodies, however, display their power of increase more particularly in their progeny, which represent the parent in an enlarged individuality. The soil, likewise constituted, as I shall presently endeavor to show, of many individuals of different character, is capable of propagating its kind by a quasi-fissiparous process—that is to say, a portion of veritable mould being isolated from the main body and placed in a favorable situation, exerts a quickening influence upon surrounding matter of elemental identity: mould, consequently, either enlarges in bulk itself, or gives bulk to vegetables, just as vegetables, during their growth, either enlarge in bulk themselvs, or give bulk to animals which feed upon them. It may be further urged, as a general proposition, that animals, plants, and the soil, increase and multiply in co-ordinate ratios, and that, with the continued addition of light, a much greater mass of matter will be engaged in the enjoyment of more exalted faculties, either in an organized or semi-organized shape.

Aboriginal soil, then, may be attributed to the rays of the sun co-operating with physical changes of certain universally diffused substances, which I shall presently mention—changes of form, consistency, and position, capable of impressing the heterogeneous residue with new affinities. We, however, regard, as *chiefly instrumental*, at the present day, in the generation of *humus de novo* from carbonic acid and water, *the forces liberated by already existing humus, or by materials of higher grade in the act of decomposition*—forces identical with those emitted from the luminous worlds around us.

Commencing with the lowest grade of progressive developments, we submit for consideration: first, whether ulmin and other semi-organized substances were not originally, and are not still, produced from carbonic acid and water at the expense of ammonia which becomes decomposed in the ground by means of oxygen, nitrogen being liberated upon the same terms which vegetables prescribe for themselves during an an-

alogous process of transformation.* Secondly, whether the disintegration of those hydrocarburets which are formed in vegetables from ulmin, such as starch, gums, oils, &c., does not promote the formation of various azotized proximate principles, when ammonia, sulphur, phosphorus, and some few other minerals, are present. Lastly, whether the dissolution of these proteine and allied compounds into less complex forms, or into their ultimate elements, does not generate cellulose, &c. The idea on which we particularly insist is, the reluctance on the part of bodies, whether organized or unorganized, to allow their constitutional forces to exhaust themselves by their component materials becoming resolved into simpler combinations, as long as contiguous matter evinces the disposition of assuming an identical character or an equivalent complexity of constitution. For this reason, the same forces which enter into the constitution of vegetables are apparently transmitted from one generation to another. But, on the other hand, it must be confessed that, were it not for the incessant appropriations of the luminous element by the surface materials of our globe, no further progress in the quantity or quality of chemico-vital phenomena could be anticipated.

It would likewise be unreasonable to expect the occurrence of these spontaneous formations of soil, where the want of indispensable prerequisites prohibits what would be an ordinary train of events in more favored regions. The fixed alkalies and ~~alkaloids~~, in moderate quantity, might expedite the process, and yet the same bases, or ammonia, or water, in excess, effectually prevent it. To consider them as tending to break up, under all circumstances, rather than to superinduce more complex relations of matter, would be to adopt an error equivalent with considering oxygen an element of universal destruction.

Viewed solely as an accumulation of dead or effete materials, the ground presents a melancholy picture of desolation, but as a thing of life it offers eminent support to the doctrine of development. As soon as a fit habitation was prepared for land-animals and plants, they each in the fulness of time entered on their career. There is an aptitude in this arrangement, and no less probable is it that the first and simplest forms of living matter derived their forces from existing substances of lower degree in complexity, and that the light of heaven co-operated then, as it does now, in the glorious consummation. Water-plants flourished long before dry land appeared; these must have subsisted upon gases and salts dissolved in the ocean, and their debris became the source of much primeval soil. This admission by no means militates against the proposition that semi-organized compounds, constituting humus, may also be formed in Nature's laboratory by a direct union of the elements concerned, the most obvious cause of a primary character being the reduction of ammonia, or its transformation, into water and nitrogen, by means of oxygen. Whether other compounds be formed in the soil, such as nitrates, which are due to progressive as well as retrograde re-

* It may be observed that the gaseous effluvia (excretions proper) respired by the leaves of plants, are for the most part simple elements, as oxygen and nitrogen, which, on assuming the aeriform condition, give up the electricity previously binding them with solids in the closest chemical relations; their loss of this force redounds to the benefit of plants by the consequent fixation of carbon.

actions, must depend upon dynamic contingencies. Holding these premises in mind, we are led to inquire whether the decomposition of semi-organized compounds did not liberate the necessary forces and introduce the lowest types of vegetable organisms, under conditions of the world more favorable than at present, and which we can scarcely now appreciate.* These in turn becoming decomposed, and surrendering their forces, may have forwarded new combinations of vegetable matter, until we reach a period of the earth's history teeming with vital phenomena familiar to us.

Germs, like nuclei of lesser note, may be identical, or nearly so, in their ultimate or proximate elements, and yet differ in the proportions of their combined imponderables. On this hypothesis the variety of vegetables and even animals is divested somewhat of mystery; the elements of nutrition being the same, the congenital forces which direct the earliest vital movements in each particular genus or species determine their subsequent figure and organization.

After making due allowance for climate and the immediate effects of solar irradiation upon the digestive powers of plants, we attach no little importance to the shape in which their food is presented to the roots. It is asserted by the modern school of Agricultural Chemists, that the organic food of plants is exclusively carbonic acid and ammonia dissolved in water, and, of course, the force of life is esteemed the chief cause of all organic changes of a progressive character. With us, on the contrary, it is contended, that the substances aforesaid could not possibly be metamorphosed into higher compounds except by the addition of light, or of forces identical with light, derived from organized and semi-organized materiel in the act of decomposition. It is well known, that no manure is more acceptable to vegetables than their own decaying leaves, or the debris of a higher class of plants; the explanation now offered for this fact by authors entitled to our utmost respect, is, as stated above, very simple; but unfortunately it leaves the solution of ulterior phenomena hopeless. To attribute the more abstruse transmutations to a force of life is tantamount to an abandonment of principles applicable to all

---

* These conditions have reference to former bipolar movements of our earth, not of an extravagant, but of an exaggerated kind. I intend, on some future occasion, to submit reasons for the belief that the sun is the immediate cause of the diurnal rotation of planets within the solar system, and of their annual changes of position and presentation. To be more explicit: if solar rays be compounded, as I shall argue, of repellent and attractive forces neutralized by their combination in light, and they be decomposed on the surface of the earth, (this surface being a mixed one of solids, liquids, and aeriform fluids,) we can understand how more of the calorific rays may be detained on the peripheral or outer portion of our planet, and exert an influence *there*, while the electric rays, for the most part, pass on to the innermost surface of the solid crust, causing additional layers to be precipitated from the central fluid mass. A temporary loss of equilibrium thus occasioned between the opposite sides of the sphere, produces a centrifugal tendency in the comparatively enlarged proximal surface, and a centripetal tendency in the distal surface, which becomes, each section of it for the instant, comparatively smaller than its antipod. We further surmise that the earth has reached its present rate of movement and extent of bipolar oscillation after considerable diminution of intensity in the North and South hemispheres respectively, at different epochs; that the approaches to a more perfect equilibrium, and consequent alterations of climate from this cause, have been so gradual within the historic period as to have escaped the notice of observers in this field of science. I am not acquainted with any more plausible explanation of the undoubted changes of level in the ocean since the commencement of the tertiary era, as evidenced by phenomena of universal extent.

physical changes for the production of which chemists are unable to control or concentrate the usual forces of matter.

Practical agriculturists will hesitate before they discard the ancient belief that proximate principles must be, and in all cases are, reduced before they can be absorbed by the roots. Because analytical chemists are unable to dissolve by artificial means divers ingredients of humus, it does not follow that a force derived from the voltaic movements of contiguous living tissues is incompetent to do so; neither does it follow that the constituents of the ascending sap vessels, or of animal chyliferous ducts, represent matter in its identical form as appropriated from the primæ viæ, or the soil, because the organic portions of food may become attached to the presenting superficial tissues, before the force of absorption separates and reduces them to other soluble compounds as found in the sap and chylous lymph. Although I have contended that the precipitation of the solids in living bodies is mainly due to forces derived from analogous materials, yet accretions to the roots of plants probably occur at all seasons; during spring and summer, however, the foliage enjoys the privilege of appropriating aeriform food by means of light, in addition to the forces borrowed from chemical and mechanical reactions.

The usual articles of food correspond more or less with the tissues which prevail in living bodies; hence it happens that, when referring to animals, practical as well as speculative agriculturists lay great stress upon fibrin, albumen, phosphate of lime, &c.; when referring to plants they formerly paid especial regard to the ordinary ingredients of humus, and while pursuing that natural system (apart from the use of highly stimulating manures, both organic and inorganic) were not troubled with the treatment or the discussion of modern vegetable diseases. We now suspect that just as there are peculiar principles in vegetables which produce constitutional effects on animals, so there are in vegetable mould of good quality combinations, not the result merely of decomposition, but of direct union between the elements concerned; and that these vegeto-mineral varieties are of great importance, and define the nicer qualifications of soil and consequent character of plants cultivated therein. The nervous matter of animals taken as food appears most likely to sustain the nervous system and to promote the growth of neurine within our own frames. No people feeding on vegetables exclusively has ever attained eminence in the scale of nations; not because neurine cannot be formed from vegetable products, but because it cannot be so bountifully formed. However much disposed the digestive apparatus may be to reduce the ingesta to a homogeneous fluid, certain substances pass its ordeal which may eventually give flavor, color, and other characteristics to both animals and vegetables.* Public opinion has changed even in respect to the elements which necessarily enter into the composition of

*A very general repugnance to truck raised upon night-soil exists, and I believe the objections are to a certain extent valid. When vegetables are supplied with but a moderate amount of such offensive manure, the probability is, that the digestive powers of the roots will completely alter the character of such portions of food as are not assimilated by the soil; or even if any is directly absorbed into the vegetable system, it is very rapidly decomposed and passed away. The case is different when plants are rendered rank and stimulated by an excess of sewage; and it is from such an unnatural and continuous process of forcing growth that we instinctively revolt.

vegetables, but is still adverse to an acknowledgement of any advantage derivable from the direct absorption of compounds highly endowed. We cannot detect any absolute contrast in kind, such as is alleged to exist, between the materials constituting the food of animals and vegetables, but simply a difference in amount of semi-organized and mineral nutriment appropriated by the races respectively, corresponding with their functions and the complexity of their organisms. The fungous and certain parasitic tribes establish this view of the subject almost conclusively. Light is necessary to their health and welfare in different degrees; its influence upon the functions of the human body being small, there is the greater necessity for man's securing a full supply of proteinized aliment, and a moderate allowance of those vegetable stimulants and beverages which administer to his gratification. It is in vain to shut our eyes to what some may consider a humiliatory fact, that diet essentially contributes to our physical and mental calibre.

From these miscellaneous data we infer that, although humus consists mainly of well-known organic matter, it contains other substances which perform an office entirely overlooked by agriculturists, and admonishes them to reconsider the necessity of frequent rotations in crops, so far as permanent improvement of the soil, and not immediate profit by overtaxing its every capability, is concerned. The staples of a country, being ascertained by experience, may be encouraged by strictly restoring to the ground the refuse of those staples as specific manure. The minute products referred to exhibit to my mind degrees of chemico-vital complexity and corresponding differences in their physiological relations. Not the least reason, perhaps, why the cerealia in particular are disinclined to extreme climates, or certain regions of country in even temperate latitudes, is the same which prevented them from sooner gracing the bosom of our earth, to wit, the want or insufficiency of appropriate semi-organized aliment. I may be told that grain has been successfully raised without the least portion of humus, or any of this highly-extolled materia alimentaria. We will join issue on this point, and await the verdict of good and true men, who will weigh the evidence of unexceptionable and long-continued experiments; and if the cerealia do not degenerate or become diseased, as potatoes have become, by the injudicious refinements of art, I shall be agreeably disappointed. There cannot, I suspect, be too great a supply of mould if there be also a proper proportion of mineral ingredients, and silica in particular, to support the luxuriant stem. While calculating the value of this class of plants we should be mindful not to underrate the straw, whether as food, litter, or manure, for domestic consumption. The tuber of potatoes has been perhaps over-stimulated by unfermented organic manures not possessing a sufficiency of mineral bases to ensure hardy germs; whereas, what seems to threaten wheat is an excess of inorganic elements over the organic, so as to render it eventually more grain than stem ; and thus by forcing year after year exuberant seed and a precocious progeny, we endanger the permanent welfare of the plant. It is true that the grain crops are not cultivated for their leaves or roots, as cabbages or turnips are; but does not the constitution of the germ depend upon the efficiency of the parent's whole structure ? The evil is analagous to that of *breeding in and in*, whereby

certain organs, peculiar products, and morbid tendencies are exaggerated to the prejudice of the other parts and functions. Such a system must terminate disastrously to animals and vegetables, as it operates injuriously to the healthy condition and growth of humus, when by repeated over-doses of any one element, or by the total neglect of others, or by allowing certain noxious elements to accumulate, we depress the productive energies of the soil.

An argument is frequently raised in disparagement of mould, that an excess of vegetable matter, as in swamps or heath-moors, is unfavorable to a wholesome vegetation : on the other hand, experiments have proved that certain plants will thrive in pure charcoal—plants which do not deserve to be styled useful except by indirection, transplanted from rich garden earth, containing abundant resources in their systems, supplied freely with water perhaps saturated with organic matter, in a close atmosphere charged with concentrated nutriment, in a green-house which collects the rays of the sun with great effect upon growth ; plants such as these, many of which cannot survive a sudden change of temperature, and die out or are forgotten in a few generations, are brought in comparison with field crops, t e support of man and his fortunes ! It may not be inappropriate, by way of comparison, to direct my readers to those conditions of society in which a pampered aristocracy is found in juxta-position with a degraded, ignorant, and vicious populace : the former are the hot-house plants, the latter those noisome weeds which from their very rankness are cumbersome to the ground. Happy is that country in which neither class exists, but a population of intelligent freemen, with such qualifications of mind and body as ennoble the race.

As far as plants administer to the food of men and domestic animals, their importance may be graduated by the amount of their fecula, gum, oils, &c., or of albumen, &c. In order to obtain these products t e plants are generally destroyed, some of them in embryo as seeds and tubers, some more advanced in life : but we never wait until these latter spontaneously cease to live, because at the period of their natural dissolution their hydro-carbonaceous deposites have been converted into lignin. The proteinized deposites in the cells and nitrogenous solutions in the sap have also disappeared ; they have done their appropriate duty, which partly corresponds with that performed by the adipose deposites in the cellular substance of animals, or by the fatty matters of bile. Vegetables, with a view to their self-preservation, are known to use the hydro-carbonaceous substances in their sap for building up their structures, at the same time borrowing, as I conceive, the necessary forces from the azotic ingredients, until the germs divert the juices measurably from the stem and branches. In consideration of the collateral uses of azotized matter in vegetables we are too apt to regard it as forming an integral portion of a plant *per se*. The vegetable and vegeto-mineral kingdoms economize nitrogen, not for its own sake, but for the advantageous reactions which it promotes : the vegeto-animal and animal kingdoms appropriate hydro-carburets chiefly for that purpose. The same principle may be extended to their modes of growth at the incipient stage of their existence ; phanerogamous flowering plants not being fecundated until the pollen reaches the blossom, nor the animal ovum until the semen masculinum quickens it.

The very compound ammonia which under favorable circumstances, such as an abundance of carbonaceous aliment, might forward the growth of plants, under other circumstances becomes the means of disintegrating their frame-work even unto utter debility and death. It is for this reason I deprecate an excessive use of, or an entire dependence upon, the fertilizing salts now so prevalent, which will probably cause a more rapid exhaustion of the soil unless we keep our farms in good heart; and *then* we may lay on the minerals with a liberal hand. Thus are true economy and high tillage combined. Our interest demands that we foster the carbonaceous elements of the soil on the Atlantic slope of this continent, in order to compete with the middle States of the West, notwithstanding the diseases of new countries which affect both animals and vegetables: nearly all of them will soon be avoided by scientific and careful husbandry, more particularly by draining. The refuse of our homesteads and green manures must be our chief resource, and in proportion as we gain carbon by any available means, we should encourage its still further accumulation by an equivalent admixture of mineral bases, among which ammonia is pre-eminently serviceable, both as a solvent or vehicle, and as a stimulant in the manner suggested.

In reply to those who consider the atmosphere competent to supply a full amount of carbon both to the leaves and roots of our field and garden crops, and who, conformably with this doctrine, rely upon mineral manures, I would ask why the ammonia which is furnished in the same way does not suffice. Can the vapor of water dissolved in air, or even the dew which is deposited at night, sustain under ordinary circumstances the welfare of the higher class of vegetables for a season, not to mention a series of years? It might as well be contended that no rain is needed anywhere, because in Egypt the periodical overflow of the Nile renders it unnecessary *there* by soaking the adjacent plains to an extraordinary depth, as that wheat can be raised on poor soil for many successive years without the slightest artificial or natural additions of carbon in some of its solid or liquid forms.

We do not propose adding compounds of nitrogen to worn-out soil solely for the purpose of raising vegetable mould, although the improvement in the soil is the first step in the improvement of our vegetables, and consequently of our animals. Whether our increase of wealth consist of azotized food which has been acquired at the expense of hydro-carbonaceous matter in vegetables, or whether it consists of hydro-carbonaceous organizable matter in the soil which has been acquired at the expense of ammoniacal ingredients, the chemical process is identical; and when the value of good mould is taken into account, the difference between the market prices of the organized and semi-organized products is not always in favor of the first.

During the decomposition of a manure heap or a compost bed, as long as ammoniacal fumes escape, provided the air be allowed to percolate the mass, and there be no deficiency of fixed alkalies and alkaline earths, I fully believe that a positive addition of semi-organized substances results; although the retention of ammonia is doubly desirable for direct appropriation by growing plants, a desideratum, which may be in some measure effected by artificial means. Were, however, the loss of am-

monia complete, which it generally is not, the porous character of the new-born mould would attract back again a certain proportion. Thus it happens that as in the atmosphere, carbonic acid, ammonia, and vapor, hold a proportionate relation to each other, so do they in the soil near the surface of the ground, and it is in consequence of the natural inability of the mineral bases to regulate their own movements satisfactorily in reference to vegetation, that man is called upon to remedy any defects or excesses. It is usually asserted by those who admit the supply of carbonic acid and ammonia to the roots from decaying organic matter, that the atmosphere was the primeval source of those elements; they therefore refer the origin of vegetables or vegetable growth to that vast magazine, as amply empowered to sustain what it originated. We admit the joint influence of gases, liquids, and solids on living bodies, and this we hold to be sufficient to account for all the material phenomena and reactions of life.

Whether this theory be right or wrong, no injury can accrue from the adoption of a practice founded on its requirements. We should by no means place our sole reliance upon the natural but slow formations of soil as food for our cul ivated crops, any more than we should rely upon the organic elements of the atmosphere, or of the same elements absorbed by ground kept in fine tilth. For precisely similar reasons we should object to feeding our domestic animals upon food slightly azotized, if our aim be to gain flesh and nerve. Under favorable conditions then, and by the aid of light, the pulverized surface of worn-out soil becomes slowly self-renovated, provided its texture be porous and yet sufficiently retentive; and this recuperation proceeds the more rapidly in proportion to the amount of semi-organized substances already existing. A nucleus assists, without being necessary to, formative action. We may not at first, or at once, attain a pabulum adapted to sweet vegetation; indeed we might never succeed without slight extraneous additions. I therefore do not recommend any purely natural system of agriculture for civilized communities; but as a question of physiology, I contend, that as a coarse vegetation precedes the development of nobler plants, so the commonest earthy bases, in conjunction with water and the elements of the atmosphere, serve to prepare poor land for future usefulness, by a succession of higher and higher subterranean products; and among the elements of air I include phosphorus, sulphur, and some other minerals, either in solution or mechanically suspended.

It is, moreover, questionable, whether the organiic acids in combination with mineral bases, or other still more abundant organic substances the constituents proper of soil, are so unstable as generally supposed; a doubt which may be extended to the constituents proper of living vegetables and animals, as long as easily-decomposable matters in the circulation or otherwise favorably located are available for functional purposes; whether, for instance, the exposure of those hydrocarburets to the atmosphere, by repeated fallows, necessarily entails their speedy loss in the absence or comparative paucity of growing plants; the latter alternative, of course, resulting in no necessary loss, provided the plants be allowed to rot on the ground or within the furrow. My own impression is, that under the circumstances stated, and as long as moisture is maintained, partial de-

composition is adequately compensated by original nitrogenized formations, these again to be supplanted in natural order by original hydrocarbonaceous deposites at the expense of the atmosphere. Uncropped land which has been kept constantly worked for several successive seasons, or which has been lying waste for five or ten years, may be gradually accumulating vegeto-mineral products peculiar to the climate, to such an extent that the application of a little guano alone will ensure a remunerating crop of grain. This is no argument in disproof of my main position, for I have uniformly discovered that, where the ground was decidedly worthless and bare, the whole class of mineral manures disappointed me; but where a scanty allowance of humus gave them a chance of turning that pittance to immediate account, the crop spoke for itself, if the season was favorable; although, as I have before remarked, it was tasking the ground to its utmost strength for the purpose of giving the crop a good start.

The constitutional depravity of the middle regions in Maryland and Virginia must be assigned to the exhaustion of available alkalies and alkaline earths, and to the too rapid withdrawal of sulphur and phosphorus. Let the proper mineral bases bear the right proportion in a raw surface composed of rock lately disintegrated, and if the climate be genial, there can be little doubt of a soil-formation, and subsequent vegetation based upon it, even on a solitary island in the midst of the Atlantic ocean.

The conclusion to which we arrive is, that animals, vegetables, and the soil hold certain properties in common, alike affecting their growth and the means of obtaining nutriment. When circumstances admit, they all appropriate materials but little if at all removed in composition from their own substance; but they also are enabled to generate within their system more or less compounds suitable to their immediate wants from the same elements in simpler states of combination. The more capital, therefore, we judicially invest in organic manures, or in mineral manures with a view of fostering humus, the more deeply we plough and pulverize the soil within prudential limits, the larger interest accrues, not only by the increased weight and quality of produce above ground, but also below the surface.

Mount Hermon, Washington County, *March*, 1850.